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Enhanced Optical Absorption and Low Energy Gap of SiC-Nanostructure-Doped PVA/PVP Blend

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In present work, films of polyvinyl alcohol/polyvinyl pyrrolidone/SiC (PVA/PVP/SiC) nanostructures are fabricated. The optical absorption is determined to use in different optical approaches. The results show that the absorbance of PVA/PVP is increased, while the transmittance is decreased with an increase in the SiC nanoparticles' concentration. The PVA/PVP/SiC nanostructures have higher absorption at high photon energy. The energy gap of PVA/PVP is decreased, when the SiC nanoparticles' concentration increases. Finally, the results on optical characteristics indicate that the PVA/PVP/SiC nanostructures can be considered as promising materials for optical fields.

У даній роботі виготовляються плівки наноструктур полівініловий спирт/полівінілпіролідон/SiC (ПВА/ПВП/SiC). Оптичне вбирання визначено для використання в різних оптичних підходах. Результати показують, що вбирання ПВА/ПВП збільшується, тоді як пропускання зменшується зі збільшенням концентрації наночастинок SiC. Наноструктури ПВА/ПВП/SiC мають більш високу абсорбцію за високої енергії фотона. Енергетична щілина ПВА/ПВП зменшується, коли концентрація наночастинок SiC збільшується. Нарешті, результати за оптичними характеристиками вказують на те, що наноструктури ПВА/ПВП/SiC можна розглядати як перспективні матеріяли для оптичних сфер застосування.

Key words: nanostructures, SiC, polyvinyl alcohol/polyvinyl pyrrolidone, absorbance, energy gap.

Ключові слова: наноструктури, SiC, полівініловий спирт/полівінілпіролідон, вбирання, енергетична щілина.

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1. INTRODUCTION

Blending polymer fabrication is the latest technique for optimizing different polymer matrices and is a valuable method for producing substances with an extensive diversity of characteristics. Polymer characteristics may be improved by combining two or more polymers and/or adding organic/inorganic fillers for use in various applications. The melt blending and solvent casting routes are the most common ways for the manufacturing of polymer blends or composites [1]. Polymer nanocomposite materials have been receiving a lot of attention lately because of the expanded range of applications that these hybrid materials can be used. It is widely documented that polymers, as dielectric materials, are good host matrices for nanoparticles, and that this is true for both metal and ceramic nanoparticles. While doing so, these embedded particles within the polymer matrix also influence the physical properties of the host. In particular, polymer ceramic hybrid composites are promising functional materials in a variety of disciplines, demonstrating useful optical, electrical, thermal, mechanical, and antibacterial characteristics [2]. Nanocomposites based on blending polymers with inorganic nanoparticles have attracted much attention owing to their projected extraordinary thermal, optical, electrical, and antibacterial properties. The motivation for using inorganic materials stems from their high thermal stability, good electrical properties and high refractive index [3].

Silicon carbide (SiC) is one of the main commonly utilized non-oxide ceramics for a lot of industrial fields relating to its attention the elevated temperature characteristics like good strength, excellent hardness, and elevated resistance for thermal shock and wear. It also has a good resistance for chemical oxidation. The performance of SiC under such great conditions is projected to allow major enhancement to a multiplicity of fields. SiC nanostructures have exposed to display superior characteristics compare to the SiC bulk. It also demonstrates the potential fields in UV photodetectors and diodes relating to a higher efficiency for light emission [4].

Polyvinyl alcohol (PVA) was used during the second half of the 20^{th} century. PVA is an artificial polymer with band gap of 5.1 eV, refractive index of 1.48, and dielectric constant of 2.44. PVA has been applied in the industrial, commercial, medical, and food sectors. It has been used to produce surgical threads, paper products, and food packaging materials. PVA has attracted considerable attention due to its attractive film-forming, good processability, biocompatibility, and good chemical resistance. This polymer is widely used for blending with other polymer compounds such as biopolymers and other polymers with hydrophilic properties. The addition of an inorganic material to the polymeric matrix is advantageous to enhance further the chemical, structural, and physical properties. PVA has hydroxide (OH) groups arranged regularly from one side of the plane to another, thus, providing interchain hydrogen-bond networks. Consequently, PVA polymers can be utilized in photovoltaic and optoelectronic devices [5].

Polyvinyl pyrrolidone (PVP) is a conjugated polymer that plays an important role in electrical conductive materials, environmental stability, and processing [6].

PVP and PVA are considered the famous and desired polymers as perfect and operative binders in the production of optical responsive materials employed in the designing of sensor systems, optoelectronics, and organic electronic systems [7].

This paper aims to prepare of PVA/PVP/SiC nanostructures to use in different optical fields.

2. MATERIALS AND METHODS

The films of PVA/PVP/SiC nanostructures were prepared by using casting method. The blend of PVA/PVP with ratio of 77% PVA:23% PVP was prepared by dissolving of 1 gm in 30 ml distilled water. The SiC nanoparticles (NPs) were added to the blend solution with different concentrations: 0.5%, 1%, 1.5%. The optical properties of PVA/PVP/SiC nanostructures' films were measured by using spectrophotometer (UV-1800A-Shimadzu).

The absorption coefficient (α) is given by [8]:

$$\alpha = 2.303(A/d), \quad (1)$$

where A is the absorbance and d is the thickness of sample.

The energy gap is calculated by [9]:

$$(\alpha h\nu)^{1/m} = C(h\nu - E_g), \quad (2)$$

where C is the constant, $h\nu$ is the photon energy, E_g is the energy gap; $m = 2$ or 3 for allowed and forbidden indirect transitions, respectively.

3. RESULTS AND DISCUSSION

Absorption spectroscopy is an analytical technique for studying the interactions between electrons in the composite film materials and radiation that can be interpreted through variations in the absorption spectra.

Figures 1 and 2 show the performance absorbance and transmittance spectra for the PVA/PVP/SiC nanostructures with photon wavelengths. As shown in these figures, the absorbance reduces, while the transmittance increases, with increase in the photon wavelength. The absorbance of PVA/PVP increases, while the transmittance decreases, with an increase in the SiC NPs' concentration that may be due to in-

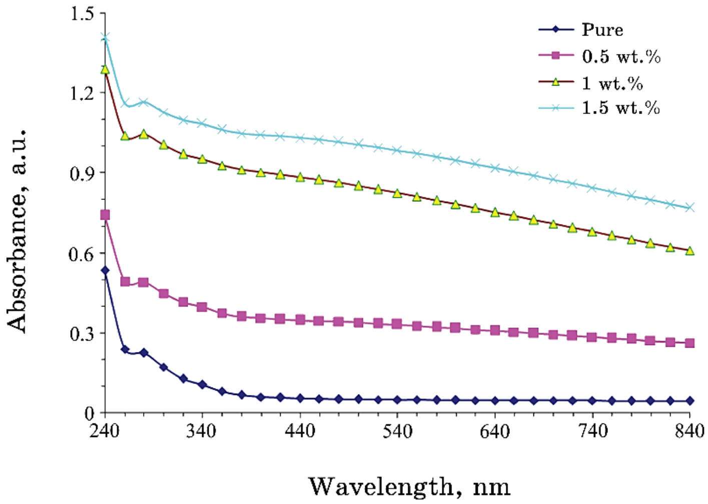

Fig. 1. Behaviour of absorbance for the PVA/PVP/SiC nanostructures with photon wavelength.

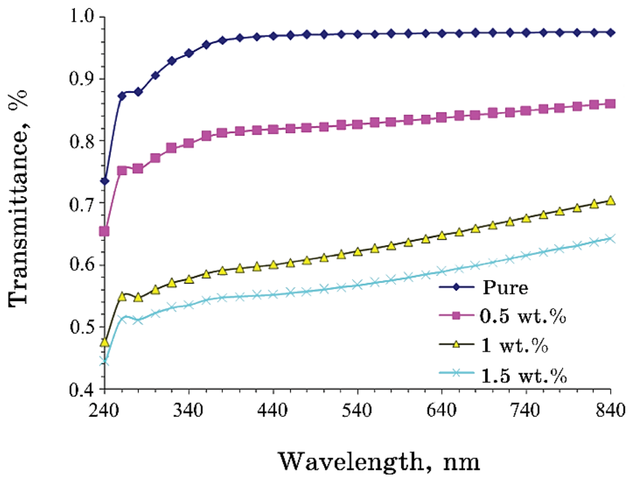

Fig. 2. Transmittance variation for the PVA/PVP/SiC nanostructures with photon wavelength.

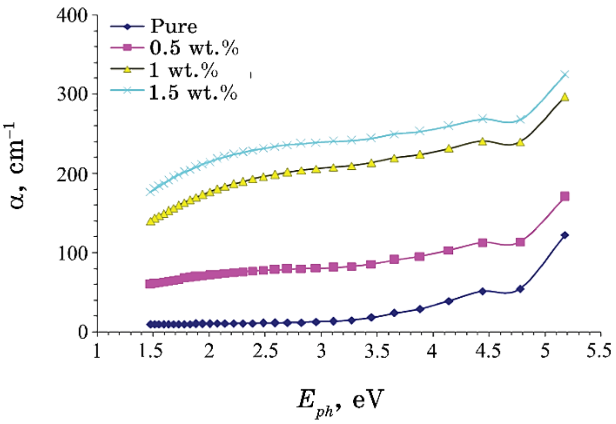

Fig. 3. Effect of SiC NPs' concentration on absorption coefficient of PVA/PVP blend.

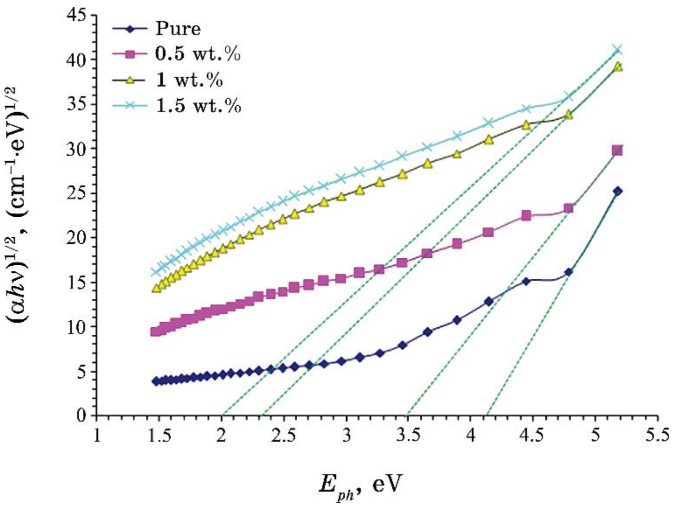

Fig. 4. Energy gap of the PVA/PVP/SiC nanostructures for allowed indirect transition.

crease in the density of charge carriers [10–17].

The effect of SiC NPs' concentration on absorption coefficient of PVA/PVP is shown in Fig. 3. The α values of PVA/PVP increases, when the SiC NPs' concentration increases. The values of $\alpha < 10^4$ cm^{-1}, and this means that the transition is indirect. The increase in α values may be related to the significant decrease in the interband transitions [18].

Figures 4 and 5 show the energy gaps of PVA/PVP/SiC nanostruc-

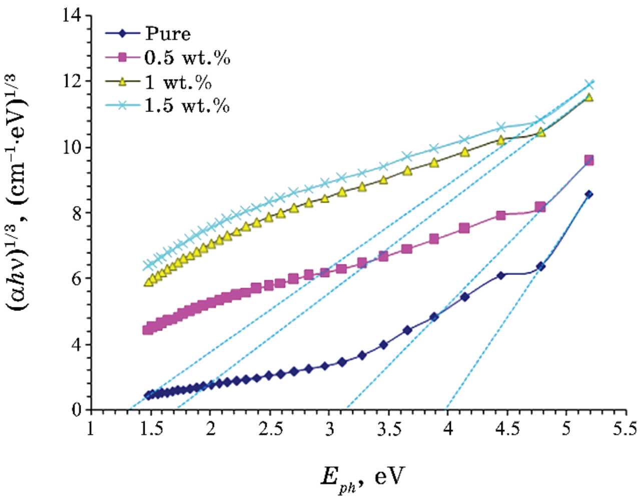

Fig. 5. Energy gap of PVA/PVP/SiC nanostructures for forbidden indirect transition.

tures for the allowed and forbidden indirect transitions, respectively. As shown in these figures, the energy gap of PVA/PVP decreases for both allowed and forbidden indirect transitions with an increase in the SiC NPs' concentration. This decrease in the optical band gap is an indicator of the change in the structure of the polymer matrix and is associated with the creation of localized states inside the band gap [19–24].

4. CONCLUSIONS

Films of PVA/PVP/SiC nanostructures were fabricated by using casting method to use in different optical approaches. The results indicate that the absorbance of PVA/PVP is increased, while the transmittance is decreased, with an increase in the SiC NPs' concentration. The PVA/PVP/SiC nanostructures have high absorption in UV-region. The energy gap of PVA/PVP is reduced with an increase in the SiC NPs' concentration. The final results for the optical characteristics show that the PVA/PVP/SiC nanostructures may be considered as promising materials for optical applications.

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